Construction of an expert system for hadron reactions

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(Received November 13, 1995)

Abstract

We have constructed an expert system for the hadron reactions based on the quark model in Prolog. The knowledge base stores many properties of hadrons and conservative laws. The expert system can infer the hadron reactions and decays using the knowledge base and inference engines. The system can also give illustrative diagrams for the resultant hadron reactions using the quark lines. It is found that the system is useful for the study of hadron reactions in the quark model.

I.INTRODUCTION

The power of the recent super-computers and parallel processing computers in numerical computations has increased tremendously. However, they are still far behind the human brain in processing complicated knowledge and can't think. Many attempts have been devoted to the studies of artificial intelligence. Although there are many successful applications, they are still in the stage of experimental study in general. One of the most important applications of artificial intelligence is an expert system. In the expert systems very complicated and highly skillful knowledge must be logically expressed. Although many efforts have been devoted to the study of knowledge processing and expert systems [1-6], still applications have been limited.

One of the earliest and most successful expert system is DENDRAL, which was made using an IF-THEN rule to identify the chemical structure. Particle physics is most fundamental and important in understanding the origin of matter as well as the origin of the universe. However, it requires advanced knowledge in quantum mechanics and field theory. Therefore, unlike popular chemical reactions it is very difficult for a non-expert to get a comprehensive understanding of particle properties and reactions. We have constructed an expert system to infer the hadron reactions based on artificial intelligence. In this communication we will present a brief outline of the expert system and the result of the demonstration. In the next section we present our expert system and in section III the usefulness of the system is demonstrated. In section IV conclusions are given.

II.THE EXPERT SYSTEM

Hadron reactions are described in the quark model. OZI rule is an important selection rule which forbids the hairpin type diagrams of the quark line. Unlike chemical reactions, in particle physics the energy involved in the reactions is so high that pair creation and annihilation are indispensable. In our system creation and annihilation of the hadrons are automatically made in inferring the reaction mechanism. The program is coded in Prolog. The organization of the expert system is shown in Fig.1. The monitor controls the five modules. The module (a) has an engine to infer the reactions for meson+proton. The module (b) has an engine to infer the meson decays. The module (c) has an engine to infer the bombarding hadron on the proton when the reaction products are given. The module (d) gives illustrative figures for the reaction process obtained in the previous engines in the quark line. The module (e) gives a brief explanation of the hadrons involved in the reaction.

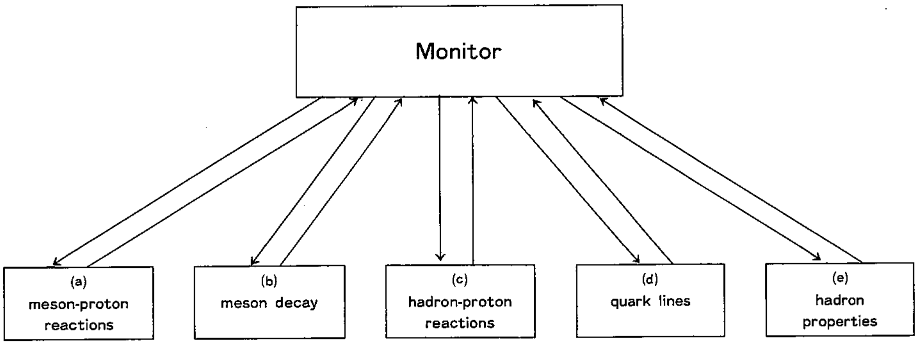

Fig.1. Illustrative diagram of the expert system. The five modules are controlled by the monitor.

Each engine has an inference module which is illustrated in Fig.2. The monitor part, which can start and end the system, controls the whole system. Each inference module

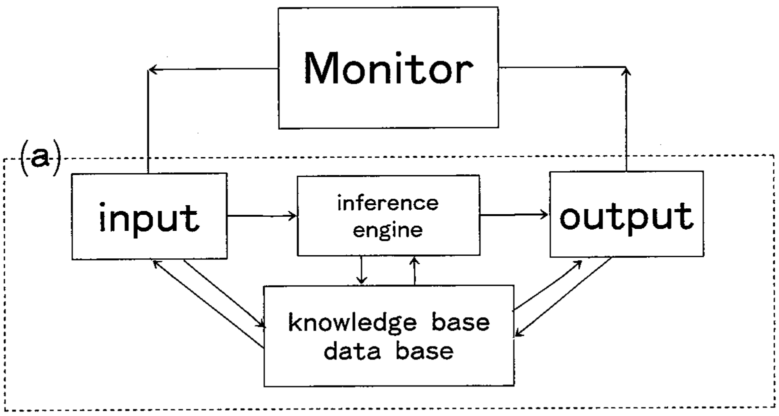

Fig.2. Each module in Fig.1 has the engine shown here.

of the hadron reactions is called by the monitor program as follows:

hadron:- prompt(p,'?'), graphics-init, elementary-particle, repeat, perform.

perform:- clear, menu1, input_sign(X), perform(X),!, end(X).

The module (a) infers the reaction mechanism when an arbitrary meson with arbitrary momentum is bombarded into the hydrogen bubble chamber and output the obtained reaction diagram in the quark lines. The control program of this module is as follows:

perform(a): - assert(p(0)), repeat, performa(N1), N1=11, abolish(p,1), abolish(a,2).

performa(N1): -p(N0), clear, per_a(N0,N,A), abolish(p,1), numbering(A,N,N1), assert(p(N1)),!.

where p(X) specifies the page that we want to see, and the 'abolish' and 'numbering' make it possible to see any page we want by storing the outputs temporally in the memory. The performa(0) controls the input module and inference module. The performa(1) through performa(10) control the output module. The knowledge base of this module includes the various properties of the hadrons such as mass, charge, baryon number, strangeness and composite quark structure. The other engines (b) and (c) also have the same inference system as the module (a).

III.RESULTS

The expert system runs on a PC where Prolog-KABA is available. We present here some of the results where engine (c) was used in the meson+proton reactions. If the reaction products as well as their momentum are given, the engine (c) can infer the hadron in the cosmic ray bombarded into the hydrogen bubble chamber and can give the reaction process. As shown in Fig.3, the system prompts us to input the observed

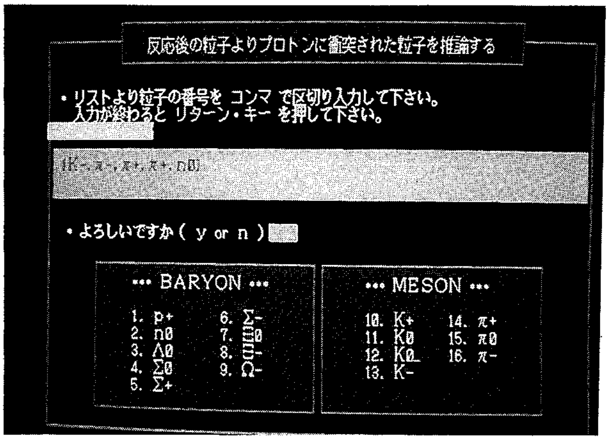

Fig.3. The picture which prompts us to input the observed reaction products. Here the observed hadrons, K^-,π^-, π^+,π^+ and n^0 input are shown.

particles. Then a user inputs the fragmented observed particles: in this case they are K^-,π^-, π^+, π^+ and n^0. The engine starts to infer the reaction process how the particles are created. The resultant reaction mechanisms are as displayed in Fig.4. Among many possibilities the system says that the n^0 and π^+ are produced as a pair from Σ^+ and π-

and π^+ are produced as an another pair from K^0. The Σ^+, K^0 and K^- are further shown to have been produced by the bombardment of the K^- on the proton. The hadrons involved in the reactions are thus inferred and the reaction mechanisms are illustrated by the system. In the inferring process many properties of hadrons and conservation laws are used. The result of Fig.4 shows that the expert system works very

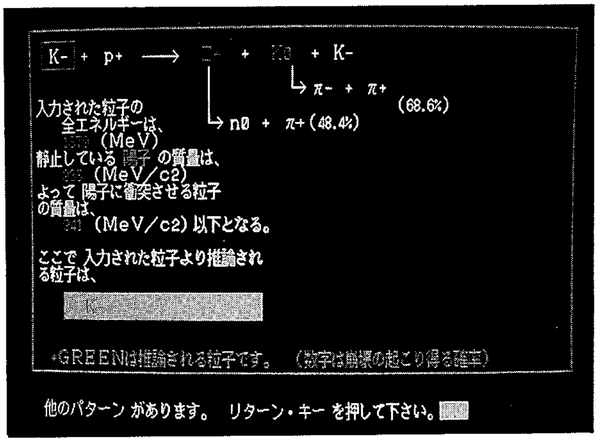

Fig.4. The picture of the reaction process inferred by the system. It is inferred that the K^- was bombarded on the proton to produce the input reaction products K^-,π^-,π^+,π^+ and n^0 in the reaction mechanism shown in this picture.

well. The module (d) produces the quark lines of the reactions involved.

IV.CONCLUSIONS

We have constructed the expert system for the hadron reactions in the quark model in Prolog. The system has three engines to infer the reaction mechanism for the input particles or the observed particles. The inferring can be performed quickly even for very complicated reaction mechanisms. It is found that the expert system is practical and useful for the study of hadron reactions. Detailed description will be given elsewhere.

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